ratio about 5.3. The result of this decrease of angle and increase of ratio is that the line of discontinuity in the free-air overruns that at the surface, producing instability, if there be great contrast of temperature, the heavier air from above descending to the surface and causing the cold front to advance faster than the storm center.

Another line of importance comes from the mathematical treatment, and that is called by the author "the boundary of the centripetal current," a curve which approaches the storm center from the southeast, crosses the cold front at a point south of, and where no motion exists relative to, the storm center, passes around the storm center to the north, and finally off again to the southeast approximately parallel to, but some distance north of, its incoming branch. Within the area determined by this line, all the air reaches the storm center and ascends; outside the line, the air moves so as to flow away to the rear of the cyclone (relative to the storm center). The width of this belt of inflowing air is at a maximum about 150 meters above the ground, and it disappears at the level where the actual wind agrees in direction with the gradient wind. The conclusion is that the storm thus removes the air within this narrow belt extending toward the southeast, and brings the air on either side of it in contact, thus making such difference of temperature as may exist manifest itself most strongly along the cold front, or squall line.

As to the steering line, or warm front, the author is not prepared to offer an explanation, but the fact that it does not always occur causes him to suggest that this line is not essential to the cyclone, but that it is a thermal discontinuity left behind by a preceding cyclone and adopted by the storm in question. This would preclude the first storm in the Bjerknesian "family" ever having a warm front.

Slight attention is given the anticyclone owing to the difficulties of making appropriate assumptions. He shows that temperature discontinuities may be produced by an anticyclone, but the temperature differences will be usually very small.—*C. L. M.*

THE TWO-AND-A-HALF YEAR CYCLE IN WEATHER AND SOLAR PHENOMENA.

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[Author's Abstract.[1]]

During the last 25 years a number of writers have called attention to a short cycle in weather elements, and estimates of its mean length have varied from 2.5 to 3.7 years. Bigelow (1894) was probably the first to mention this cycle which he regarded as one-fourth of the sunspot cycle, or 2¾ years, but subsequently referred to it as a 3-year cycle. Later investigators include Lockyer (1902–1908), Arctowski (1909), Braak (1910), Wallén (1910), Johannson (1912), Krogness (1917), and Helland-Hansen and Nansen (1917). Those who regarded the length of the cycle as 3 to 3.7 years employed annual means, thus obscuring some short fluctuations of small amplitude, while those who made the length 2.5 to 3 years, as Arctowski, Wallén and Helland-Hansen and Nansen employed consecutive 12-month means.

In the present investigation the author has employed the two 12-month means centering January 1 and July 1, the latter being the ordinary calender-year mean. The annual variation is eliminated, while the large departures of the colder months are grouped together in the January 1 mean. A plot of these two yearly means satisfactorily exhibits the short cycle, although in some cases the existence of a maximum or minimum phase is indicated only by an inflexion in a continuous ascent or descent of the curve, due to a longer variation. The amplitude of the short cycle is, generally, however, sufficiently large in comparison with that of the variations of longer period, as the 7 or 11 or 35 year cycles, so that the determination of the maximum and minimum phases is, as a rule, quite unaffected by the existence of the longer cycles.

The object of the investigation has been to determine, to the nearest quarter-year the maximum and minimum phases of the cycle as far back as temperature records are available—1770 in the United States and 1730 in Europe. Pressure records from 1740 in Europe have also been examined and serve to confirm the epochs derived from the temperature curves. Rainfall curves exhibit the cycle with much less regularity than temperature and pressure. Contemporaneous curves for several stations have been examined during the entire period of time for mutual confirmation and elimination of instrumental errors, change of exposure, or location and the small differences normally occurring between localities more or less distant from each other. The United States records from 1770 to 1923 yield a mean interval of 2.30 years between successive maxima and minima of the cycle. The mean deviation of the intervals from this mean is 0.35 year, while the mean variability is 0.34 year. The latter measure of dispersion being even smaller than the mean deviation, while normally it should be 1.4 ($\sqrt{2}$) times greater, indicates the existence of marked secular variations in the length of the cycle. A plot of the phase intervals from 1770 shows a highly irregular variation about the mean interval, 2.30, ranging from 2 years or less about 1775, 1815, 1850, 1880, and 1910, or the epochs of maximum rainfall in the Brückner cycle, to 2¾ or more years at the intermediate dates. There is also a marked tendency to a shortening of the cycle within a few years after each sunspot maximum in the 11-year cycle. The range of this 11-year variation is about one-half that of the 35-year variation. The mean duration of the cycle from European data beginning 1728 is 2.20 years. This lower average is due to the low average, 2 years, of the period 1728–1770. There is furthermore apparent from the plot a progressive increase in the length of the cycle from the middle of the eighteenth century to the present time, which is, in all probability, due to a long cycle of about 300 years. A point to be emphasized is that the cycle changes in length gradually, not abruptly. The epochs of high and low temperature in Europe and the United States, east of the Rocky Mountains, are, on the average, practically coincident, Europe averaging 0.06 year later. The individual differences from true coincidence average about six months, and 85 per cent of these differences are between ±0.75 year.

From inspection of the curves of temperature it is apparent that the amplitude at the above-mentioned epochs of maximum rainfall in the Brückner cycle is perhaps only one-half the amplitude at the opposite epochs, 1800, 1830, 1865, 1890, and 1925. At Portland, Oreg., the length of the variation was about 2.20 years and the mean amplitude 1.5° in 1880 and 1910, while in 1890 and 1920 the values were 3 years and 3°, re-

[1] The complete article, of which this is an abstract, will appear in a later number of the REVIEW.

spectively. Regarding the relations between pressure and temperature it is found that over southwestern Europe the epochs of low pressure slightly precede, about 0.3 year, the epochs of low temperature over the United States and Europe, while on the other hand, at the same time the pressure is high over western North America. Correlation between the pressure in Spain and the pressure at St. Paul, Minn., during the period 1875–1918 gives −0.41, while with the temperature at St. Paul the correlation is +0.65. There is also apparent a lag, or time interval, between regions differing in longitude and latitude. For example, the epochs at Portland precede those at Toronto by about 0.75 year, and St. Paul precedes New Orleans by about 0.35 year.

Bigelow and Lockyer employed solar prominence data to show solar relations with terrestrial weather. The prominence data are, however, inadequate, owing to the necessary limitation of the observations to the solar limb. I have employed, therefore, the Greenwich measurements, half-yearly means, of the mean heliographic latitude of the entire spotted area since 1875. When an 11-year variation is eliminated and minor fluctuations smoothed out, there is disclosed a well-defined cycle, averaging 2¼ years, during which period the excess of spots shifts from one hemisphere to the other and back again. When a curve of these solar variations in latitude is compared with a curve of temperature, as for example, St. Paul, it is apparent that each epoch of low temperature is preceded by a corresponding epoch of spot excess in the Northern Hemisphere, the average interval of time intervening being about 1.25 years. This time interval varies with the Brückner cycle, being about three-fourth year in 1880 and 1915 and 1¾ years in 1895. Correlating the solar and temperature data for the period 1875–1923 for simultaneous values and also for successive lags in the temperature data varying by half-yearly intervals, the following results are obtained. For simultaneous values the result is set opposite zero in the tabulation below; shifting the temperature curve to the left in successive half-year intervals the results are as shown. Values for the solar Northern Hemisphere are called +.

0	+0.40	6	−0.63
1	−.51	7	+.15
2	−.56	8	+.60
3	+.26	9	+.31
4	+.60	10	−.50
5	+.15	11	−.31

This table shows that the phases of the two curves come into approximate conjunction and opposition with each other as the temperature curve is successively shifted to the left, on an average of about every 2¼ years, since the maximum correlation coefficients of like sign occur about 4½ half-yearly intervals apart.

Wolfer's smoothed sunspot numbers since 1750 when plotted, and the primary 11-year variation graphically drawn thereon to smooth out the minor fluctuations, disclose secondary maxima averaging 2¼ years apart, with epochs corresponding to terrestrial temperature epochs at definite average time intervals therefrom. While owing to the nature of the early sunspot observations these epochs are not quite as satisfactory as the epochs since 1875, there is sufficient evidence to indicate that the cycle has persisted since 1750, and that its length has varied synchronously with that of the meteorological cycle.

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